Quantifying Acoustic Uncertainty Due to Marine Mammals and Fish Near the Shelfbreak Front Off Cape Hatteras

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LONG TERM GOALS

The long term goals of our work on acoustic uncertainty due to fish and marine mammals are to: 1) understand the nature of low-to-medium frequency (100-2000 Hz) acoustic scattering (specifically reverberation and attenuation) by fish schools and larger marine mammals, 2) advance our acoustic methods of quantitatively imaging fish schools and tracking vocalizing marine mammals, and 3) understand the correlation between the detailed physical oceanography and the biology and acoustics.

OBJECTIVES

Our primary objectives this year were: 1) perform our “year two” major experiment off Cape Hatteras, N.C. to measure the acoustics, biology, and physical oceanography of fish schools and (if present) marine mammals, 2) continue analysis of our “year one” survey cruise data, and 3) compare the year one and year two results, as this comments on the variability in the ecosystem.

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APPROACH

The basic tools/methodology employed in our "year two" major cruise consisted of a combination of: 1) an AUV mounted acoustic source, 2) moored multi-element SHRU acoustic receiver arrays, 3) a shipboard acoustic resonator, 4) fish-attraction devices (FAD's), 5) a three-AUV fish-field mapping effort (employing sidescan sonar plus optics) and 6) ScanFish, ADCP, and moored sensor oceanographic field mapping. Our day-to-day experimental plan was to: 1) survey the oceanography at night to find the shelfbreak front and other features that might attract fish, 2) survey for fish during the day based on the oceanography survey results, 3) given a good fish population "target", deploy the SHRU receivers and FAD's and perform REMUS vehicle operations to both map the fish school and examine its 500-2000 Hz scattering characteristics, 4) work an area for a few days, and 5) then go to next candidate operational area.

WORK COMPLETED/ACCOMPLISHMENTS

The major accomplishment this year was the successful execution of our major cruise off Cape Hatteras. The cruise, which went from May 13-May 30, 2012, was very productive overall, though the results in some cases were not what we expected based on the pilot cruise and climatological data (which in itself is interesting.)

Another accomplishment this year was the analysis of the year one pilot cruise data, which provided both a first test of our techniques, and also a baseline for the year two main experiment. Also, a suite of signal processing programs has been developed this year. This program package allows data extraction from the SHRU recorders, matched filter processing, pulse compression and frequency analysis.

RESULTS

There were rather immediate results from our experiment in terms of measuring the local biology, and also from the oceanography. The acoustic scattering results will need a longer term analysis effort, and we hope to have results from that component of the experiment by next year. All the data, including the acoustic scattering data, were of high quality, so we expect to have some measure of success in attaining our original scientific goals. The signal processing programs developed this year can readily be used to process the acoustic data.

Though there were a number of interesting initial results, we will just highlight a few of them as a representative sample. The first was the simultaneous mapping of the fish field, along with making the acoustic measurements of scattering. A 3D track of three AUV's mapping the fish field during a typical deployment is shown in Figure 3, along with the positions of the SHRU receivers and the FAD. Also, a single image frame from a GoPro HD camera video is shown in Figure 4 for a fish school trailing one of the REMUS vehicles. (A camera was attached to each AUV, so that we would have both optical and sidescan sonar imaging of the fish and larger animals.)

Another important immediate result of the main experiment was that both the water mass characteristics and the fish species (warm water versus cold water fish, specifically) had shifted significantly and unexpectedly between the pilot experiment and the main experiment. During the pilot experiment, we saw typical hydrographic conditions over the outer shelf, with normal cold pool temperatures. However, during the main experiment in May, we observed a considerable warming

relative to previous measurements, of 5°C. This had a substantial effect on the fish species which were observed, as expected cold water fish were not observed by the AUVs or caught from the ship. The magnitude of this warming is very surprising, and is consistent with sea surface temperature observations from satellites. We also observed, during the pilot experiment, a greatly enhanced buoyant outflow plume from Chesapeake Bay as a result of runoff from Hurricane Irene (Gawarkiewicz et al., 2012).

IMPACT/APPLICATIONS

The impact of our experiment should be: 1) an increased understanding of the scattering of sound through fish schools, which can help discriminate fish schools as "false targets" for sonars, 2) improved methods for mapping fish populations and schools, which is important in that the "biological field" is often an unknown for both experimental studies and Navy applications, and thus could be quantified, and 3) a beginning understanding of how climate change may be affecting shallow water acoustics, both through the fish, and perhaps more importantly, through the ocean temperature field.

TRANSITIONS

Being able to model the acoustics of fish schools will allow them to be discriminated against as false targets ion sonar systems. Also, in the case of larger shoals, the effective attenuation due to the fish can be estimated. Further, the ability to incorporate fish and climate change into Navy models could be a useful payoff.

RELATED PROJECTS

This work is related to the work of K. Benoit-Bird and her work off the west coast of the United States as well as T. Stanton and D. Greenbaum who are working on theoretical aspects of fish school behavior and the scattering of sound within fish schools. This work also relates to efforts to quantify uncertainty in acoustic propagation from the Quantifying, Predicting, and Exploiting Uncertainty DRI.

PUBLICATIONS

A. Recent Publications (refereed)

B. Recent Publications (non-refereed)

Gawarkiewicz, G., F. Bahr, A. Kukulya, C. Marquette, C. Linder, T. Grothues, and J. Dobarro (2012). "Cross-shelf structure on the continental shelf north of Cape Hatteras: impact from recent flooding." Poster presentation, AGU Ocean Sciences Meeting, Salt Lake City, UT.

Kaela Vogel and Thomas Grothues (2011). "Automatic pelagic fish detection by area distribution in side scan sonar images", Poster presentation, Institute of Marine and Coastal Studies, Rutgers University.

Daniel Wo (2012). "Locating fish and other acoustic scattering targets from video from an underwater camera attached to a remus 100 during the Fish Uncertainty 2012 experiment", Summer Student Report, WHOI.

C. Outreach Projects

The Atlantic Shelfbreak: Using robotic vehicles to observe ocean life
http://www.youtube.com/watch?v=v0OYJzyxAZc&feature=youtu.be

Fig. 1. "Snoopy" REMUS vehicle, with 500-2000 Hz acoustic source near nose.

Fig. 2. SHRU acoustic receiver units being deployed off Cape Hatteras to listen to the acoustic source on the AUV, as well as to ambient noise.

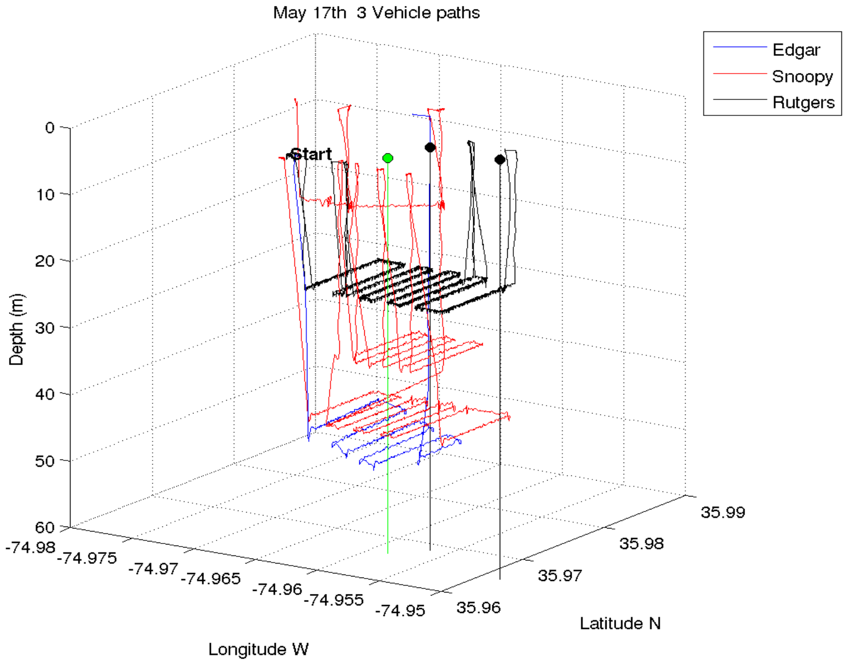

Figure 3. 3D volume view of three AUV's mapping the fish distribution in the experimental volume (Edgar, Snoopy, and Rutgers AUV's) while the Snoopy vehicle with a 500-2000 Hz source transmits sound that will scatter off the fish and go to the SHRU receivers. [Two black dots represent the SHRU moorings. Green dot is the fish-attraction device (FAD).]

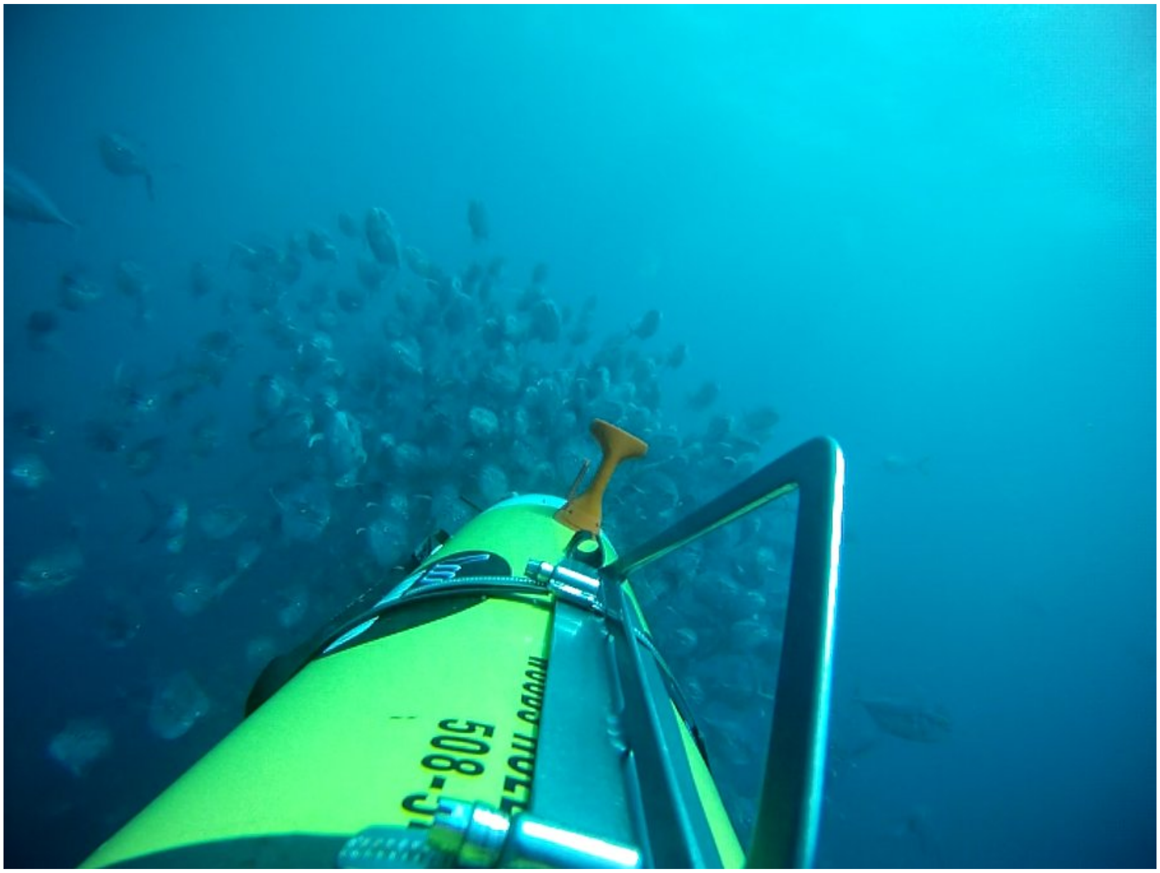

Fig. 4. A school of Blue Runners (Caranx crysos) tracks our Snoopy AUV in the experimental volume.
[Based on both the visual and sidescan sonar imagery, we should have adequate targets for our acoustic scattering studies.]